§18. Heat Transfer from a Large Flat Surface to the Pressurized He II in a Simulated Channel

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Characteristics of heat transfer in a rectangular simulated channel for the large superconducting coil which will be cooled with the pressurized superfluid helium (He II$_p$) have been investigated. Subcool He I layer in contact with a large heated surface exposed to He II$_p$ expands the non-boiling region beyond the Kapitza region up to q_n above which the nucleate boiling sets in. As the bath temperature decreases, q_n is increased more rapidly than q_λ at which the superfluidity is broken at the center of the heated surface[1]. The value of q_n is also increased as the channel gap length increases. Furthermore, q_n is independent of the channel orientation as well as q_λ. This is quite different from the fact that the peak heat flux at which the film boiling occurs depends on the orientation because of the induced flow of the coolant.

Reduction in the temperature of coolant in the channel due to the latent heat has been detected in He II$_p$ above q_n as well as in the saturated He II [2]. This behavior in the characteristics results in the increase of the heat transfer coefficient in the film boiling state. Besides, increments in the equilibrium heat flux of the equal area condition [2] can be brought about due to the elevated peak heat fluxes above q_n.

The sophisticated stabilization of large superconducting coils can be established by taking the non-boiling limit q_n into account. The temperature rises of the coolant surrounding hot spots of the superconductors may be restrained below 4.2 K without the bubbles which will reduce the break down voltage between layers.

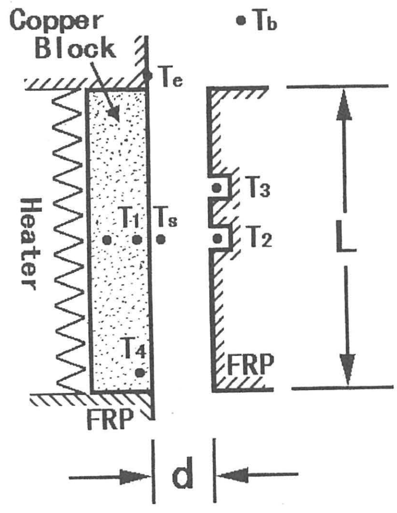

Fig.1 Arrangement of the tested channel and positions of germanium thermometers, L:length, d:gap of the channel.

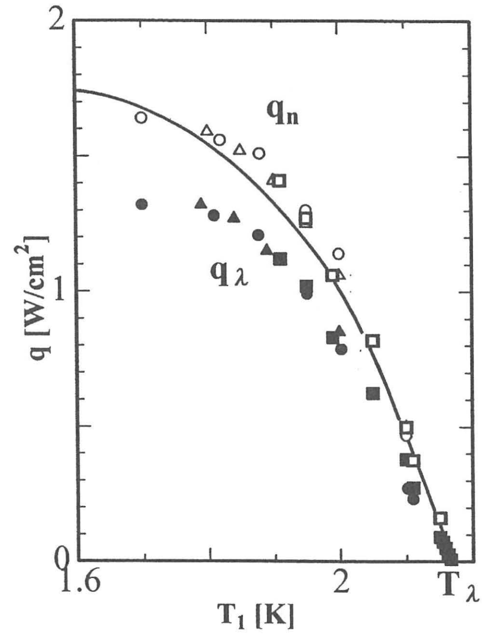

Fig.2 Critical heat fluxes as a function of bath temperature Tb.
q: Heat Flux / unit heated surface area (Q/Acu)

References

1) Gorter, C.J. and Mellink, J.H., Physica 15 (1949) 285
2) Turuga, H and Kobayashi, H, Cryogenics 31 (1993) 365
3) Maddock, B.J. et al: Cryogenics 9 (1969) 261